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NOTES ON GLACIATION IN THE SANGRE DE CRISTO RANGE, COLORADO¹

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In connection with an examination of the artesian basin of the San Luis Valley, Colorado, in 1903, several opportunities were had to make observations in the Sangre de Cristo Mountains, and various notes on the glaciation of that range are here recorded.

Attention has heretofore been called to glaciation on the eastern slope of these mountains by J. J. Stevenson,² who describes and figures the well-developed Grape Creek moraine, about midway of the range north and south. F. M. Endlich³ also alludes to small indications, of glaciation, so uncertain in their character that he prefers to disregard them altogether. As a matter of fact, not only has the range suffered general glaciation, but even at present contains two living glaciers.

No pretense is made to completeness, individually or collectively, for the following notes. The observations were for the most part confined to the western side of the range. The sharp precipitous western slope merges into the great alluvial slope which skirts the western base of the range. Each stream valley which heads against the crest-line has its valley trains of glacial débris, which ordinarily reach down to and, at an elevation of about 9,000 to 9,500 feet above tide, crown the alluvial cones making up the alluvial slope.

The northernmost glaciation observed is in Black Canyon, just east of Orient Station on the Denver & Rio Grande Railway. Here are lateral moraines on each side of the creek 100-200 feet in height, and reaching nearly or quite to the lower end of the canyon.

The next canyon to the south in which morainic deposits came to the notice of the writer is Willow Creek, east of the village of Crestone.

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² *U. S. Geographical and Geological Survey West of the 100th Meridian*, Vol. III (1875), pp. 434, 435.

³ *U. S. Geological and Geographical Survey of the Territories, Annual Report*, 1875, p. 220.

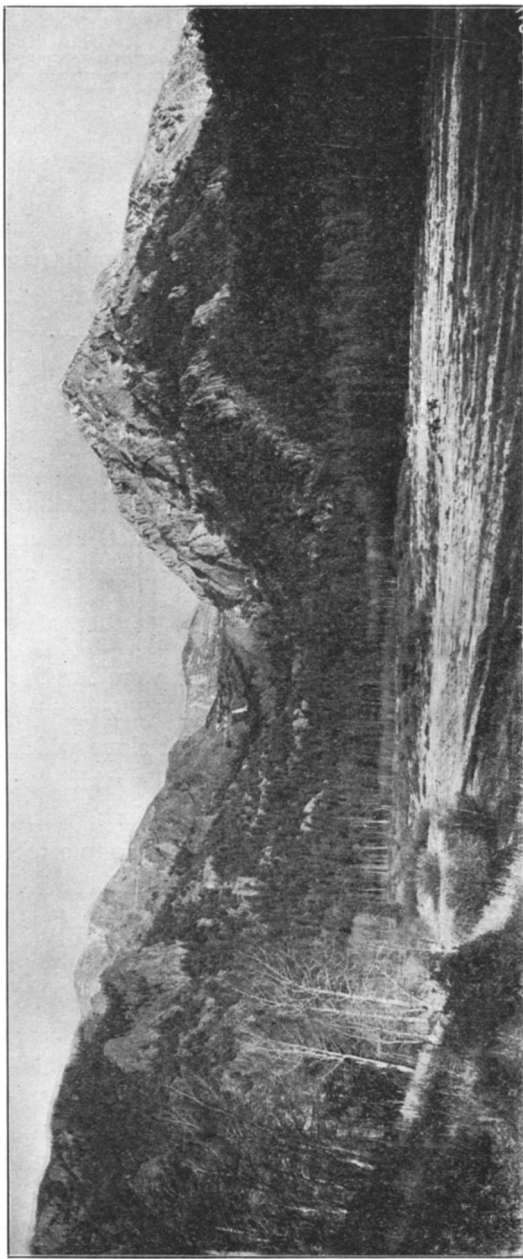


FIG. 1.—Willow Creek Park, looking up the glaciated trough of Willow Creek.

The view looking up this creek (Fig. 1) shows Willow Creek Park in the immediate foreground. This is a natural meadow, 80 or 100 acres in extent, formed by the draining of a glacial lake. Two existing lakes are found in Willow Creek Valley above the park—one a beautiful, clear, deep pool half-way between the Park and the summit, and the other a smaller one in the cirque at the head of the creek. Polished surfaces, striae, and other evidences of glaciation are common all along the valley.

The next moraine visited was that of South Zapata Creek, the northernmost of the circle of radial streams which head in the Blanca massif. This moraine, as seen in the distance, just crowns the crest of the great alluvial fan which Zapata Creek has built. The foot of the moraine has an elevation of about 9,000 feet, and is 1,400 feet above the level of the valley at the foot of the fan in the vicinity of Zapata ranch house. There are two concentric moraines, the outer one about 50 feet the higher. The front of the outer moraine is about 350 feet in height. Both are covered with large boulders. The inner one formerly inclosed a small lake, the outlet of which cut through the moraine where it adjoined the canyon wall on the north side and, once incised in the rock, has continued to cut back a narrow winding cleft, sometimes not more than two or three feet wide, down through which the water pours, forming the picturesque Zapata Falls. A lake also exists near the head of the creek.

Middle Creek, the next stream to the south, exhibits a similar crescentic moraine crowning the great spreading alluvial fan over which large boulders are scattered from crest to base.

Bear Creek heads against the crest of the range just north of Blanca Peak. There is a very small lake in the cirque at the head of the creek, two or three small ponds down the creek some distance, and a fine little lake about 2,500 feet below the summit in altitude. There is little morainic material to be seen in the valley above the elevation of 10,000 feet. The valley is rounded and glaciated up the sides to the overhanging cliffs, but in places the glaciated portion is covered by "slide rock" or talus from the cliff. A light fall of snow will hang on the unglaciated slope and on the talus, but not on the cliffs, and after such snows the height to which the ice occupied the various creek valleys can be plainly seen from the center of San Luis Valley. At

10,000 feet elevation the trail up the creek crosses over the upper moraine on the south side, and the view shown (Fig. 2) is from this point. There are here inner and outer moraines, the latter 125-150 feet the higher. The inner moraine extends the farther out on the fan, differing in this respect from the Zapata moraines. The height of the moraine from its foot on the fan to the top of the outer ridge is approximately 500 feet. Landslides in the moraine show its constitution to be true glacial *débris*.

The various streams descending the south slope of Sierra Blanca likewise held their appropriate glaciers. The moraine in Little Bear



FIG. 2.—Moraines on north side of Bear Creek. Inner moraine forms a bench covered with a growth of pines.

Creek reaches barely to the mouth of the canyon at the apex of the fan. Blanca Creek has a pronounced moraine, extending beyond the mouth of the canyon and down the slope of the fan, the older, outer moraine reaching the farther, and the inner one being the higher. The two branches of Ute Creek both exhibit moraines and glaciated contours, and contain several lakes in their upper courses. The various streams which head in the Blanca massif number in their valleys some thirty lakelets, large and small.

The valley of the Huerfano, heading on the northeast side of Blanca Peak, is distinguished from the others by the presence of living glaciers—small, it is true, but characteristic. The valley of the Huerfano, up to the base of the steep north side of Blanca peak,

is a U-shaped valley with meadows and grassy patches, the lower slopes well rounded and glaciated. The lower limit of glaciation is beyond the region of the writer's observations.

On the north side of the valley, at the junction of the granite and the quartz conglomerate, a small valley has been cut out, and in this has formed the very pretty example of talus glacier shown (Fig. 3.). This mass of *débris* is about a third of a mile long and about 150

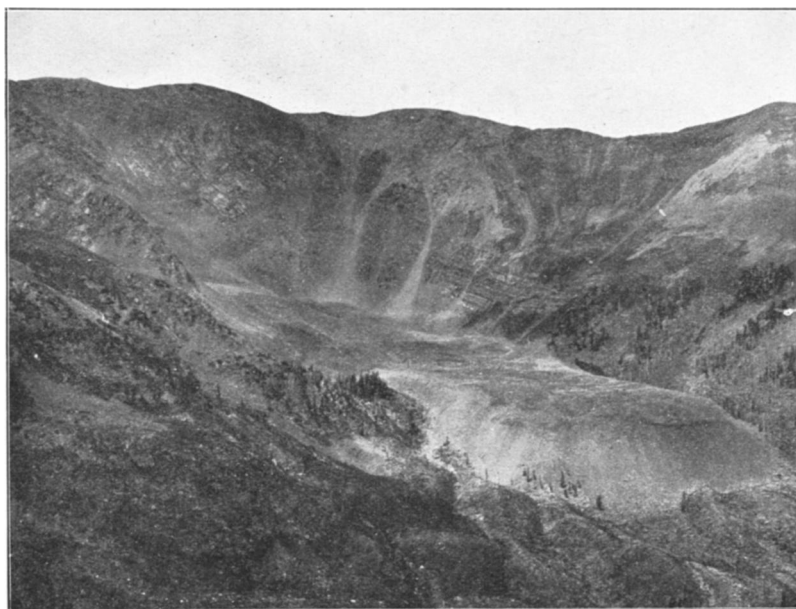


FIG. 3.—Talus glacier in small valley entering Huerfano Valley from the north, three miles north of Blanca Peak.

feet high at its lower termination. In the valley below several morainic trains may be seen emerging from beneath the talus glacier, showing that true glaciation preceded the formation of the talus glacier, which, from its bareness of vegetation and steep slopes, seems to be relatively recent in age. Streams of rocky material can be seen descending on to the *débris*, which has a remarkably smooth outline to have been formed through the agency of avalanches alone. Intermingled snow and ice must have played an important part in its formation.

The Blanca glaciers lie snugly under the steep north face of Blanca Peak as will be seen in Fig. 4, taken from a point about a half-mile north of McMillan's mine, which appears in the foreground. The glacier on the left, mostly covered with fresh snow, is the smaller. The surface of this glacier shows many small longitudinal gullies and another system running transversely. These seem to be largely due to



FIG. 4.—Blanca glaciers from the northeast.

original wind ripple-marks in the snow into which dust has settled, melting them deeper.

The north glacier, the one on the right, is shown in a nearer view (Fig. 5), taken from the moraine immediately below it with the camera tilted upward somewhat. Figure 6 is a view northward across the same glacier from a point near the southern one. These two views display the glacier very well. The width of the glacier is about 800 feet, and its greatest length is about 1,000 feet, although the ice probably extends a considerable distance farther beneath the terminal moraine. The glacier lies in a pocket on the mountain side, and the ice is prob-

ably quite thick. A prospecting tunnel, starting in the moraine below the edge of the visible ice, went horizontally in the clear ice

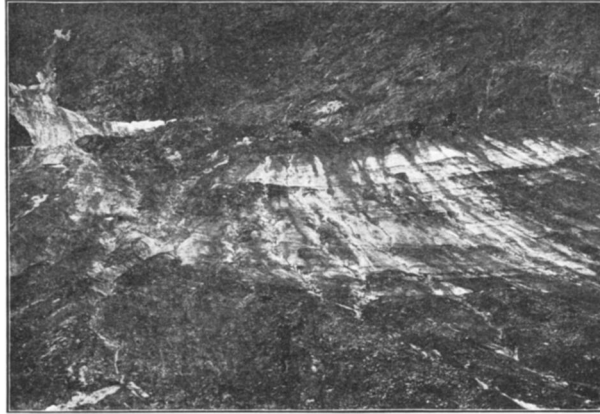


FIG. 5.—Blanca glacier, from moraine below.



FIG. 6.—Blanca glacier, looking north.

for a distance of 115 feet without reaching rock, which, taking into account the slope of the surface, demonstrates a vertical thickness of

over 80 feet. The slope of the ice surface is very steep, about 42° —quite too steep for climbing without alpinestock and ice-creepers. Two embryonic terminal morainic ridges are visible, the lower and larger one some 400 feet below the present edge of visible ice. The ice, as will be noted, shows the characteristic upturned dirt bands looped concentrically about the point of supply, and the surface of the lower half of the glacier is for the most part covered with fine black gravelly dirt, residual from the dirt bands. Many small longitudinal rivulets have cut gullies down the otherwise notably smooth surface of the ice, exposing the banded ice beneath the dirt covering. The ice itself displays characteristic *gletscherkörne* about one-tenth inch in diameter. Because of the conformation of the pocket in which the ice accumulates, the production of crevasses is impossible, with the exception of a definite *bergschrunde* which marks the line where the upper edge of the ice pulls away from the rock wall in the wasting season. The precipice above and the steep face of the glacier cause loose fragments falling upon the ice to attain great velocity in their passage across it, so that examination of the glacier is attended by considerable danger from these flying rocks.

The Blanca glaciers possess an added interest in being the southernmost existing glaciers yet reported in the Rocky Mountains, and, so far as known to the writer, the southernmost in the United States. Their latitude is $37^{\circ} 35'$ N., their longitude $105^{\circ} 28'$ W., and their elevation about 12,000 feet.

Summary.—The various stream valleys heading against the crest of the Sangre de Cristo Range held Pleistocene glaciers, the morainic remains of which fall into two systems, showing the existence of two periods of glaciation. The moraines of both systems are comparatively fresh-looking, and the outer, older ones are not noticeably more eroded than, or different topographically from, the inner, later ones. The inner moraines are sometimes lower, sometimes higher, than the outer ones, and while they usually are shorter than the older moraines, sometimes, as in Bear Creek valley, they transgress the older moraine and extend farther out upon the alluvial slope, these irregularities being due presumably to variable local conditions in Pleistocene time.